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Exploring a cardio-thoracic hospital ward soundscape in relation to restoration

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ABSTRACT

Hospitals can provide stressful experiences for both patients and medical staff. A well-designed hospital soundscape should avoid adding to negative emotional states (e.g. stress), limit any detrimental cognitive effects (e.g. attentional fatigue), and enable restoration. Experiences of the cardio-thoracic ward soundscape, in a UK public University hospital, were explored via semi-structured interviews with 11 patients and 16 nurses. Thematic coding analysis resulted in 11 key themes including notions of restoration and emotional responses. The themes were used to develop a conceptual model to describe the processes involved in the perception and evaluation of the soundscape. The language used by patients and nurses indicated the emotional response to the soundscape was at times stressful and at others potentially restorative. Coping methods of accepting and habituating to individual sounds were noted. The impact of the patients' and nurses' ability to maintain these coping strategies are discussed in relation to restoration and the temporal variation of the soundscape. A period of 'quiet time' was in operation at the hospital and the importance of this was noted through various responses relating to emotion and restoration. The results suggest the soundscape has potentially, a beneficial role in facilitating restoration thus helping patients' recovery and medical staff's ability to remain productive. This research supports the need to study hospital soundscapes further so that design implications can be considered for the production of a more restorative environment, possibly through the masking/removal of unwanted sounds and optimising positive sounds.
Keywords: Soundscape, Restoration, Healthcare

1. INTRODUCTION

The nature of working within, or being admitted to a hospital can often be a stressful experience for the medical staff and the patients. It is therefore important that the environment is not an additional, unnecessary, factor that contributes to stress levels and is detrimental to an individual's health and healing. All features of the environment play a role in how an individual feels, thus as well as considering the functionality of a ward and its visual features, the sounds within the environment need to be studied. A well-designed hospital soundscape should avoid adding to negative emotional states (e.g. stress), limit any detrimental cognitive effects (e.g. attentional fatigue), and enable restoration.

Healthcare environments have been subject to much research assessing their sound levels and the critical effects that excessive sound levels can have, such as sleep disturbance, annoyance, and communication interference [1]. A report for the World Health Organization therefore recommends low sound levels for healthcare environments [1]. Research into hospital sound levels often use these guidelines as a comparison to show that in practice these desired sound levels are generally exceeded

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[2-5]. Joseph and Ulrich [6] report that excessive sound and noise increase work pressure, stress, annoyance, fatigue, and burnout among healthcare staff. Critically, sound levels of 77dB(A) within an operating theatre had a detrimental effect on staff's mental efficiency (errors) during an operation [7]. Additionally Gurses & Carayon, in an exploration of major performance obstacles in intensive care nursing, found 46% of respondents cited noisy work environments as a problem [8]. This included features such as alarms, phones ringing, and conversations [8]. Indeed, Topf [9] describes the sound within hospitals as an 'ambient stressor' which is likely to cause subjective or physiological stress on nurses. The sound within healthcare environments is therefore important to consider for reducing staff stress levels and the likelihood of them making errors.

Soundscape research offers a way to explore the array of responses to sound in the environment and to consider more than just sound levels. It also facilitates an extension of the prior research focus on the negative effects of sound, including stress, to consider the positive effects of soundscapes. This concept of positive sound has been previously researched in the context of the urban environment [10-13]. This approach enables an assessment of the extent to which existing soundscapes offer patients and nurses an opportunity for restoration.

Restoration can be both physiological and psychological. Hospital patients need physiological recovery but they may also need psychological restoration from dealing with their potentially stressful and negative situation. Environments that promote psychological restoration can also help patients' physiological recovery from health problems and reduce stress levels [14]. Attention Restoration Theory describes restorative environments as enabling recovery from attentional fatigue and reflecting upon daily events and any problems [15]. If individuals are attentionally fatigued they are likely to make more errors, have reduced productivity and higher stress levels [15], all of which are problems that arise in hospital staff [16]. Psychological restoration in hospitals is therefore important to help a patient's physiological recovery and increase positive feelings, while for staff it may help decrease errors and reduce stress levels. The problems that arise from noisy healthcare environments coincide with the attributes that restoration can help relieve. Therefore hospital soundscapes should also be considered when aiming to create a restorative environment on a hospital ward.

The aim of the presented study was to assess patients' and nurses' perception of a cardio-thoracic ward soundscape by exploring how it made them feel and what aspects of the soundscape people considered as positive and negative. In addition to describing the emergent themes from people's responses a conceptual model was developed mapping this perception of the soundscape. This paper re-examines the responses in relation to Attention Restoration Theory and builds a rationale for future work to look at testing soundscape interventions.

2. Method

2.1 Participants and Design

An interview schedule was developed, consisting of key questions that covered three areas; the general environment, sound in the environment and improvements to the environment. The interview schedule was piloted on seven healthcare professionals. No modifications were made but this allowed refinement of the interview and coding analysis.

Semi structured interviews were conducted with patients and nurses in a cardio-thoracic ward at a UK public hospital due to the general condition of the patients and the presence of various monitoring devices. Interviews ranged from 7-19 minutes in duration. Patients were interviewed at their bedside within the ward bays. Two of the interviewed patients were in single rooms off the main corridor. Interviews with nurses were held within an office just off the main corridor. For consistency between participants, interviews were started with a prewritten script detailing the aims of the study and the interview procedure. All were recorded on an electronic Dictaphone, and transcribed verbatim.

In total 27 participants were interviewed. The sample size was dictated by reaching theoretical saturation, which is defined as the point upon which no new properties, dimensions or relationships emerged [17]. Eleven patients were interviewed, nine male and two female, with a mean age of 68 years and an average stay of 6.8 days in the ward. Sixteen female nurses with an average experience of 19 years of working in the healthcare environment were interviewed.

2.2 Analysis

Content analysis of the language used by the participants was conducted. For a fuller understanding, interview transcripts were coded using Thematic Analysis as part of the Grounded Theory approach

[17] to extract the key themes and categories. Categories were smaller ideas held within a theme, which specifically related to the soundscape. To start to define these emerging themes and categories from the data, analysis of the transcripts started after conducting six interviews; three with patients and three with nurses. The coding schedule was developed by methodically analysing each transcript. This continued throughout the data collection process until theoretical saturation was reached.

Once an initial coding framework had been developed this was refined and checked by re-coding the transcripts a further three times. An external reader (a colleague with relevant experience) then analysed three randomly selected interview transcripts to check the validity of the coding framework, upon which the coding framework was refined and all transcripts re-coded. Axial coding was used whereby related themes and categories were explored [18] and constructed forming a conceptual model for understanding the perception of the soundscape.

A second post-hoc phase of analysis was also conducted whereby the language used and some themes that had emerged were re-examined with a focus upon their relationship to Attention Restoration Theory.

3. RESULTS

3.1 Language for Describing the Environment

A list of all the adjectives used by the participants describing the soundscape and how they felt was created. Both patients and nurses used positive and negative terms to describe the environment and the way it made them feel. Interestingly, patients tended to use positive terms, such as "*lovely*" and "*encouraging*" (59% of adjectives), while staff tended to use more negative terms, such as "*horrendous*" and "*manic*" (58% of adjectives). A post-hoc re-examination of the adjectives identified a number of references directly relating to stress ("*stressed*", "*stressful*") and others related to possible symptoms of attentional fatigue "*frustration*", "*disruptive*", "*irritating*".

The nurses used more words relating to stress than the patients (8 compared to 1, respectively). In particular, the soundscape was described by one nurse as "*quite stressing when you're trying to co-ordinate or have conversation with relatives...quite disruptive*". However both groups used more words associated with feelings of irritability which can be exasperated by attentional fatigue, including "*annoying*" and "*disturbing*" (10 by nurses, 12 by patients). Again the production of unnecessary sounds was a problem; "*someone comes crashing through with rattley pots or something...and I think did they really have to do that?*"

Many of the adjectives (39%) used in the interviews to describe the environment in a positive way related to attributes that can be associated with restorative environments (e.g. "*relaxed environment*", "*recharging*" and "*calming*"). In addition, terms emphasising the soundscape in a positive way also suggested that it could help provide a restorative environment (e.g. "*peaceful*", "*lovely and quiet*" and "*tranquil*"). Nurses in particular referred to the calming aspects of the environment, thereby highlighting the importance of the provision of a restorative environment to help them from the stressful nature of many other aspects of the environment they had mentioned.

3.2 Developed Themes and Conceptual Model

The interviews revealed 11 key themes subdivided into 37 categories upon which theoretical saturation was achieved. The predominant theme that emerged from participants' comments related to their perception and interpretation of the sound (38%). This was categorised by the perception of the sound in positive or negative ways including the sound's impact on behaviours such as sleeping and work. It also included a category on accepting or becoming habituated to sounds, as well as comments about the sounds level. Responses relating to specific sound sources were also frequently mentioned (16%) as were emotional responses to sounds or other environmental features (12%). The other themes each accounted for less than 10% of the comments, but included comments about temporal factors (9%), restoration (6%), design improvements (5%) and people's behaviour affecting perception (3%).

The themes and categories which emerged from the interviews led to the construction of a conceptual model that maps the processes involved in people's responses to healthcare soundscapes (Figure 1). First, the specific sound sources and their sound levels create the existing sonic environment, which can be dictated by temporal factors of daily routines within the hospital ward. Second, there is an initial interpretation of these sounds as information and stimulation, which can be necessary or problematic. Depending on the meaning provided by or given to the sounds the individual may then accept or habituate to the soundscape. This may be influenced by the intervening conditions

(e.g. other environmental features, behaviours, and job duties) that also affect the perception and interpretation of the sounds. The individual's emotional responses are either in a positive or negative depending on if the coping method has been met. Restoration may or may not have occurred during this time. Altogether, these features result in a final evaluation of the healthcare soundscape.

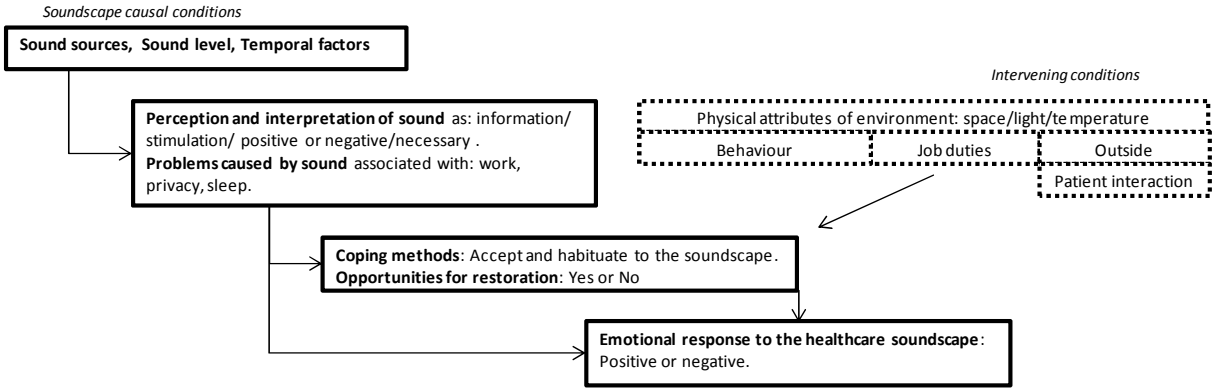

Figure 1 – Conceptual model developed from interview data with patients and nurses showing key features in the perception of a healthcare soundscape.

3.3 Coping Methods

Within the framework, coping methods referring to the ability of the individual to deal with the soundscape, became a key feature in the conceptual model as it is an additional bridge from the physical soundscape attributes to the emotional response of the individual. Three such approaches were described by the interviewees; i) habituation (becoming accustom) to some sounds, ii) acceptance of some sounds, iii) a designated period of 'quiet time'.

For both nurses and patients, certain sounds (e.g. occupational sounds, some monitor sounds) became habituated too as they were part of the everyday ward soundscape. These sounds were often occurring and did not need to be attended to as they did not provide meaningful information for the individual at that point in time; **"***Because you are in the environment, you know you're doing your job; you're not taking that moment to stop and listen...but the sounds you can hear...we just forget them*" (Nurse).

Habituation arises, after the sounds have been accepted. For the nurses, this has already occurred as they have spent longer periods of time in the ward and are accustomed to the different sounds and what they mean; "*It's definitely a case of these are the sounds in your work place and you accept them...so you have a sort of level of tolerance that they are below if you like*" (Nurse). In contrast, although the sounds are novel at first for the patients, they become accustomed to them and accept the soundscape as part of being in hospital. This acceptance occurred for sounds resulting from a range of activities, such as from the cleaning of the ward ("*how it is*"; Nurse) to hearing other people ("*It's just part of being in hospital. Being in hospital you can't expect people to be quiet...especially when they've all had operations and different things and they're in pain sometimes, and getting in and out of bed. It's just acceptable*"; Patient). Patients also accepted sounds once they understood them. For example, a patient learning that a fellow patient was not screaming in pain resulted in the sound being accepted rather than producing a negative emotional response.

In the cardio-thoracic, a 'quiet time' was in place. This was a one-hour period after lunchtime where activities were kept to a minimum to allow patients to rest. The existence of this quiet time can be described as a way of managing and coping with the level of sound that is produced at other times of the day. This acknowledges that the soundscape has an effect on the patients and this provides a period that facilitates restoration.

3.4 Restoration – Visual and Sound

The theme of restoration naturally emerged from the data in relation to both visual and acoustic features of the environment. As to be expected, there were also links and associations between these two sensory categories, as the visual features are providing or encouraging the existence of the sound sources. For example, patients spoke of the positive association of a view over a green space (visual restoration) while another patient commented on the positive effect in hearing birdsong from the green

space the ward overlooks "*it's gorgeous here because I have the birds* [pointing out the window] *and when they open the windows and things like that it's gorgeous - ideal that situation*" (acoustic restoration). This combination of seeing and hearing nature was seemingly important to those situated by windows and highlights the influence the external environment has on people within the hospital ward.

The concept of restoration particularly emerged when participants discussed the period of quiet time. When asked about the benefits of quiet time, its value was clear from patients comments; "*I think it's very important to have that quiet time*", "*it's nice just to be able to have a bit of quiet time and have a bit of a kip...helps with the healing process, I'm sure it does*". The nurses also benefitted from this period of quiet time, "*Everything is much much calmer. Phone calls happen but I don't feel stressed because it's quieter*". Quiet time, is therefore a beneficial coping 'strategy' for both patients and staff for dealing with the hospital soundscape as it affects their emotional and restorative responses. Three nurses clearly stated the benefit of having quiet time, describing it as "a *recharging time for both patients and nurses*". The psychological benefits of restoration, in terms of an individual's ability for directed attention (an individual's ability to effectively engage in a task), was also clearly identified as occurring during quiet times; "*Patients are resting; nurses have settled back into their routines and got rid of all the chaos...You can concentrate on what you're doing and what you've got to do*". In other words, the forced quietness reduces the amount of distractions for the nurses thereby allowing directed attention (e.g. "*concentrate*") to occur more easily and a period of "*recharging*" from any attentional fatigue.

Quiet time also allowed a period of restorative reflection and positive feelings for both the patients and nurses, "*It's peaceful...it's not often quiet but it's nice when it is peaceful. It's nice to be able to listen to yourself... it's much more calming when it's quieter*" (Nurse). Patients also commented on quiet time contributing to their healing process, therefore when the soundscape is perceived as positive it results in an overall positive feeling.

An improved soundscape did not just arise though from the removal of various sound sources by reducing activity levels during quiet time. The soundscape was also perceived to be improved by the introduction of desirable sounds. For example, one patient with dementia could be heard by others screaming and music was played within the environment to help calm the patient. The presence of the music, however also had positive effects for the other patients "*in the afternoon they put music on for her. It's quite low but we can just about hear it. Now that makes us feel better*" (Patient). The music was therefore a desirable sound for some people and in this occasion helped remove the negatively evaluated sound of another patient screaming. Therefore, various sounds can provide a positive emotional response and facilitate attributes of restoration, including masking, as long as they are accepted and understood within the context of the environment.

4. DISCUSSION

The study proved successful in extracting the subjective perception of a hospital soundscape and how it makes the individual feel. This allowed a conceptual framework to be developed, which maps the physical attributes of the soundscape into the emotional response of the individual. Subtle differences between the language used by the patients and staff to describe the soundscape highlight differences in the way in which a soundscape is perceived, because of the associated meanings the sounds have for the individual. Patients tended to be positive towards the soundscape, which reflects well on the specific cardio-thoracic ward that was studied. In contrast, the staff tended to focus slightly more on the negative aspects of the soundscape, in particular in relation to its stressful nature. This reflects nurses and other healthcare workers commonly reporting problems of stress, burnout, and fatigue levels that are higher than those in the general population [16, 19]. These negative feelings may result in an increased reporting of negative aspects of the environment as staff's irritability levels are enhanced. Together this highlights the unnecessary additional burden that environment features, including the soundscape, can have on staff. Feelings of irritability are associated with attentional fatigue [15] which explains nurses' focus on restorative words when describing positive aspects of the environment including the soundscape, as it gave them time for reflection and attentional recovery, thus increasing their ability to concentrate. Kaplan [15] suggests that directed attentional fatigue is the key ingredient in ineffectiveness and human error. In the healthcare context this could be attributed to medical errors or poor job performance. Therefore, opportunities for increasing the staff's ability to concentrate are particularly important within this context, with one approach being to make improvements to the soundscape so that it provides a restorative environment.

Restoration was a theme that emerged from the data. Related categories whereby sound impacted on sleeping and work, also suggest restoration is needed to help counter these problems. Quiet time in particular was found to be a restorative period for both patients and staff. For the nurses they were free from distractions that demanded their attention thus draining their cognitive resources which enabled them time to focus and reflect. The absence of sounds and reduced sound levels therefore had a positive effect on everyone in the ward, which is in line with the recommendations by the World Health Organisation [1]. However, it should be noted that the absence of negative sound does not necessarily create a positive environment [20] and this was true of people's evaluation of the hospital soundscape. Being able to hear natural sounds from outside was perceived as desirable by the patients as it improved their positive emotions and was potentially restorative. Hearing sounds of nature are positively related to individuals' restoration [21] thus the introduction of such desirable sounds can help improve people's evaluation of and responses to the healthcare soundscape, which is in turn beneficial for their well-being. The remarks about the natural sounds and window views also emphasises the need to consider how the external environment influences the evaluation of a hospital ward and its soundscape, rather than focussing on the internal ward in isolation. The introduction of music into a ward however is more complex, as it is does not necessarily fit the hospital context and people vary in their opinions towards music, unlike the general approval of hearing sounds of nature [22] emanating from any visible green spaces. In this instance, the music was understood and accepted as a means to calm a woman screaming and was enjoyed, but at other times masking in this form may be considered an unnecessary addition to the soundscape.

Coping mechanisms for dealing with the hospital soundscape were informally in place on this ward, through the use of a 'quiet time', which seemed to be successful in restoring staff in particular. Other coping methods were also used such as accepting and habituating to certain sounds. These latter two mechanisms can be positive and provide temporary relief from any negative effects or evaluation of the soundscape. An acceptance of the sounds involves an understanding of why they are occurring which subsequently influences the positive or neutral meanings attributed to the sounds and the resulting emotive response. Habituating to sounds that are considered annoying can be positive but may eventually cause the individual's cognitive facilities to become drained, potentially resulting in attentional fatigue and/or stress. Indeed, the soundscape was a factor in causing stress for both patients and staff, but also provided periods where restoration was facilitated. Therefore, without opportunities for restoration – as provided by the 'quiet time' or positive sounds – habituating to a soundscape may not be sustainable for long periods.

The results are limited in their generalisability as they are specific to the cardio-thoracic ward and the general patient demographic found within them. However, by examining people's perception of the soundscape through identifying emergent themes and Attention Restoration Theory, it is shown that the soundscape has the potential to hinder or enable restoration and influence the persons emotional response. This paves the way for laboratory and in-situ investigations to test interventions (such as natural sounds, masking sounds and providing information to facilitate acceptance and habituation of sounds) to assist restoration and improve the emotional response to the ward soundscape to be carried out by the authors.

5. CONCLUSIONS

The study found that the soundscape is an important environmental feature of the cardio-thoracic ward and one that is more complex than alluded to by simple sound level measurements. It was found that both patients and staff habituate to the soundscape and in doing so this helps elicit a more positive rather than negative emotional response. Quiet sound levels were found to be a feature contributing to the notion of restoration, along with natural sounds. Thus the absence of certain sounds e.g. occupational, for a set period enabling other sounds e.g. natural, to become prominent produced a positive cognitive effect (in the reduction of perceived stress) and a positive emotional effect on both the patients and staff. Therefore, although low sound levels are clearly important in the overall perception of the environment (as evident by the success of 'quiet time') the content of the soundscape is equally important, for the well-being of patients and staff. Using this holistic approach, the creation of a more positive soundscape can now be explored experimentally, to consider the relationship between sounds and their contextual meaning for patients and nurses, for the ward soundscape.

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REFERENCES

1. B. Berglund, T. Lindvall, and D. Schewela, *Guidelines for Community Noise*. 2000, World Health Organisation: Geneva, Switzerland.
2. N. Akansel and S. Kaymakci, *Effects of intensive care unit noise on patients: a study on coronary artery bypass graft surgery patients.* Journal of Clinical Nursing, 2008. **17**(12): p. 1581-1590.
3. D.P. Anand, T.N. Wenham, and A. Bodenham, *Measurement of noise levels in an intensive care unit.* Anaesthesia, 2009. **64**(7): p. 794-794.
4. I. Hagerman, et al., *Influence of intensive coronary care acoustics on the quality of care and physiological state of patients.* International Journal of Cardiology, 2005. **98**(2): p. 267-270.
5. M.A. Tijunelis, E. Fitzsullivan, and S.O. Henderson, *Noise in the ED.* American Journal of Emergency Medicine, 2005. **23**(3): p. 332-335.
6. A. Joseph and R. Ulrich, *Sound Control for Improved Outcomes in Healthcare Settings*. 2007, The Center for Health Design.
7. V. Murthy, et al., *Detrimental effects of noise on anethetists.* Canadian Journal of Anaesthesia-Journal Canadien D Anesthesie, 1995. **42**(7): p. 608-611.
8. A.P. Gurses and P. Carayon, *Exploring performance obstacles of intensive care nurses.* Applied Ergonomics, 2009. **40**(3): p. 509-518.
9. M. Topf, *Hospital noise pollution: an environmental stress model to guide research and clinical interventions.* Journal of Advanced Nursing, 2000. **31**(3): p. 520-528.
10. W. Davies, et al., *The positive soundscape project: A synthesis of results from many disciplines*, in *Inter-noise* 2009: Ottawa, Canada.
11. R. Cain, et al., *Emotional dimensions of a soundscape*, in *Inter noise 2009*. 2009: Ottawa, Canada. p. 8.
12. R. Cain and P. Jennings, *Developing best prectice for lab-based evaluations of urban soundscapes*, in *Inter-Noise*. 2007: Instanbul, Turkey.
13. R. Cain, et al., *An activity-centric conceptual framework for assessing and creating positive urban soundscapes.* Proceedings of the Institute of Acoustics, 2008. **30**(2).
14. R.S. Ulrich, et al., *Stress recovery during exposure to natural and urban environments.* Journal of Environmental Psychology, 1991. **11**: p. 201-230.
15. S. Kaplan, *The restorative benefits of nature: Toward an integrative framework.* Journal of Environmental Psychology, 1995. **15**(3): p. 169-182.
16. S. Helps, *Experiences of stress in accident and emergency nurses.* Accid Emerg Nurs, 1997. **5**(1): p. 48-53.
17. A. Strauss and J. Corbin, *Basics of Qualitative Research. Techniques and Procedures for Developing Grounded Theory*. 2 ed. 1998, London: Sage Publications.
18. G. Gibbs, *Analysing qualitative data*. 2007, London, UK: Sage Publications.
19. G.E. Hardy, D.A. Shapiro, and C.S. Borrill, *Fatigue in the workforce of national health service trusts: levels of symptamatology and links with minor psychiatric deisorder, demographic, occupaitonal and work role factors.* Journal of Psychosomatic Research, 1997. **43**(1): p. 83-92.
20. B. Truax, *Acoustic communication*. 1984, Norwood, N.J.: Ablex Publishing Corporation.
21. S.R. Payne, *Urban sustainability, psychological restoration and soundscapes*, in *Psychological approaches to sustainability. Current trends in theory, research and applications*, V. Corral-Verdugo, C.H. García-Cadena, and M. Frías-Armenta, Editors. 2010, Nova Science Publishers Inc: New York.
22. W. Yang and J. Kang, *Soundscape and sound preferences in urban squares: a case study in sheffield.* Journal of Urban Design, 2005. **10**(1): p. 61-80.